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Colorado AQMA Area Source Emission Inventory

PEDCo-Environmental Specialists, Inc, Cincinnati, Ohio

Prepared for

Environmental Protection Agency, Denver, Colo Air Planning and Operations Section

Nov 75

EPA-908/1-76-003
NOVEMBER 1975

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COLORADO AQMA AREA SOURCE EMISSION INVENTORY

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
AIR & HAZARDOUS MATERIALS DIVISION
DENVER, COLORADO 80203

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16. ABSTRACT

This report contains emission estimates for non point sources of air pollution in AQMA counties of the State of Colorado. Estimates for particulate, carbon monoxide, sulfur oxides, hydrocarbons and oxides of nitrogen emissions are made for the base year (present), 1980, and 1985. Methodologies and data sources are presented.

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PEDCo-ENVIRONMENTAL
SUITE 13 • ATKINSON SQUARE
CINCINNATI, OHIO 45246
513/771-4330

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Prepared by

PEDCo-ENVIRONMENTAL SPECIALISTS, INC.
Suite 13, Atkinson Square
Cincinnati, Ohio 45246

Contract No. 68-02-1375
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EPA Contract Officer: David Kircher

Prepared for

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Region VIII
Air Planning and Operations Section
Denver, Colorado 80203

November 1975

BRANCH OFFICES

Suite 110, Crown Center
Kansas City, Mo. 64108

Suite 104-A, Professional Village
Chapel Hill, N.C. 27514

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Material included in this report was not originally intended for publication, but to document the data sources and assumptions made in preparing the area source emission inventory. Therefore, the text may be sketchy and the report more useful as a resource document than a general procedures manual for emission inventories. It should also be pointed out that the area source emission inventory is subject to frequent updating so that data presented herein may soon become obsolete.

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SUMMARY

This document presents a baseline air pollutant emissions inventory of area sources in the five Colorado Air Quality Maintenance Areas (AQMA's)--Larimer-Weld Counties, the Denver Metropolitan Area, El Paso County, Pueblo County, and the Colorado-Utah Oil Shale Area. All are designated for particulate matter and carbon monoxide; the Oil Shale Area also for sulfur dioxide and oxidants; Larimer-Weld for oxidants; and Denver for nitrogen oxides and oxidants.

The area source emission estimates in this report are for each AQMA county. These county-wide emissions are to be allocated to sub-county areas (grids). Grids are necessary to define spatial distribution of emissions when modeling the transport and diffusion of air pollutants. A model will be used to determine air quality or pollutant concentration at various locations.

The area source categories included in the inventory are shown in Tables 1 through 5 of this Summary. The inventory considers all conventional source categories described in APTD-1135, Guide for Compiling a Comprehensive Emission Inventory,[1] plus additional categories for fugitive dust, portable point sources, and industrial processes with less than five tons each of emissions. One category, vessels, was considered to be negligible and therefore not included.

A base year of 1974 was used in the inventory to be consistent with the point source inventory also being prepared. Also, 1974 was the most recent year in which data could be obtained.

Emission estimates were made using the most recent emission factors from AP-42, Compilation of Air Pollutant Emission Factors, Second Edition.[2] In some cases, the emission estimates for a source category are an update of the 1973 statewide area source inventory done for EPA by TRW[3] or the 1972 inventory of fugitive dust sources done by PEDCo-Environmental.[4] However, in those categories where more information has become available, a different calculation procedure has been used to estimate emissions.

An abbreviated format has been used to minimize repetition of material covered by the TRW report, to make the report more easily usable as a working reference, and to still properly document the data. Each source category is discussed in a separate section of the report.

Table 1. 1974 PARTICULATE AREA SOURCE EMISSIONS BY COUNTY

SOURCE CATEGORY	ADAMS	ARAPAHOE	BOULDER	CLEAR CREEK	DENVER	DOUGLAS	GILPIN	JEFFERSON
Fuel combustion								
Bituminous coal	475	512	769	2	3,053	18	7	1,053
Distillate oil	42	45	37	2	117	3	1	64
Residual oil	32	36	37	1	135	2	Neg	59
Natural gas	75	67	85	2	268	3	Neg	76
Other fuels	595	884	619	32	1,751	62	14	1,066
Incinerators, on site	4	10	2	3	3	Neg	0	4
Mobile sources								
Highway	*	*	*	*	*	*	*	*
Off highway	68	60	50	7	175	3	Neg	90
Railroads	25	13	17	0	46	16	4	10
Aircraft	1	7	3	0	92	Neg	0	2
Fugitive dust								
Unpaved roads	19,675	13,803	13,932	2,890	1,300	8,848	2,804	27,677
Sand on paved roads	2,231	1,910	1,333	Neg	7,664	Neg	Neg	2,681
Paved roads	1,431	1,225	887	171	4,424	387	26	1,784
Agriculture	3,478	1,209	4,819	0	0	215	0	196
Land development	312	270	57	4	Neg	519	1	226
Construction	423	290	303	10	788	113	8	350
Quarrying, mining & tailings	320	416	1,352	1,419	0	328	33	1,056
Aggregate storage	453	204	0	0	58	202	0	119
Cattle feed lots	117	0	98	Neg	Neg	Neg	Neg	Neg
Other								
Area process particulates	61	18	7	0	2	6	0	7
Portable particulate sources	41	Neg	Neg	Neg	Neg	15	12	11
Forest fires & slash burning	Neg	Neg	78	1	Neg	23	1	27
Agricultural burning	120	20	181	Neg	Neg	6	Neg	52
Total	29,979	20,996	24,667	4,543	19,876	10,770	9,011	33,611

*Not updated in this report.

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Table 1. (continued). 1974 PARTICULATE AREA SOURCE EMISSIONS BY COUNTY

SOURCE CATEGORY	EL PASO	PUEBLO	LARIMER	WELD	GARFIELD	MESA	MOFFAT	RIO BLANCO
Fuel combustion								
Bituminous coal	536	620	348	331	28	146	15	23
Distillate oil	59	28	25	27	5	13	1	71
Residual oil	43	27	21	19	2	9	1	1
Natural gas	93	39	32	24	5	18	3	6
Other fuels	1,094	491	453	366	66	228	27	65
Incinerators, on site	4	2	1	1	1	Neg	0	0
Mobile sources								
Highway	1,103	481	452	585	118	254	63	31
Off highway	84	39	37	33	5	18	2	1
Railroads	32	47	32	87	18	21	2	0
Aircraft	31	8	1	1	Neg	1	Neg	1
Fugitive dust								
Unpaved roads	53,231	17,521	24,149	62,104	20,766	24,669	33,244	12,109
Sand on paved roads	3,260	Neg	527	403	Neg	474	Neg	Neg
Paved roads	2,382	1,015	819	1,118	277	507	103	53
Agriculture	13,293	4,115	14,472	52,229	438	2,223	296	92
Land development	3,663	459	214	39	132	27	Neg	Neg
Construction	685	207	226	294	160	124	32	7
Quarrying, mining & tailings	Neg	104	2,520	88	160	80	80	0
Aggregate storage	69	104	0	33	6	52	0	8
Cattle feed lots	0	44	102	682	Neg	Neg	Neg	Neg
Other								
Area process particulates	5	12	5	14	0	9	0	0
Portable particulate sources	8	0	15	2	Neg	14	23	Neg
Forest fires & slash burning	126	2	70	0	28	26	6	11
Agricultural burning	30	295	108	916	25	68	55	5
Total	78,751	25,665	44,625	119,396	22,188	28,984	33,954	12,341

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Table 2. 1974 SULFUR DIOXIDE AREA SOURCE EMISSIONS BY COUNTY

SOURCE CATEGORY	GARFIELD	MESA	MOFFAT	RIO BLANCO
Fuel combustion				
Bituminous coal	26	58	12	25
Distillate oil	23	66	7	7
Residual oil	8	43	3	3
Natural gas	Neg	1	Neg	Neg
Other fuels: LPG & wood	Neg	Neg	Neg	Neg
Incinerators, on site	Neg	Neg	0	0
Mobile sources				
Highway	52	106	30	14
Off highway	5	18	2	1
Railroads	41	48	4	0
Aircraft	Neg	5	Neg	1
Other				
Forest fire & slash burning	Neg	Neg	Neg	Neg
Agricultural burning	Neg	Neg	Neg	Neg
Total	155	345	59	50

Table 3. 1974 CARBON MONOXIDE AREA SOURCE EMISSIONS BY COUNTY

SOURCE CATEGORY	ADAMS	ARAPAHOE	BOULDER	CLEAR CREEK	DENVER	DOUGLAS	GILPIN	JEFFERSON
Fuel combustion								
Bituminous coal	47	14	53	6	106	13	Neg	21
Distillate oil	12	12	11	1	33	1	Neg	18
Residual oil	6	6	6	Neg	23	Neg	Neg	10
Natural gas	150	133	170	5	536	6	1	125
Other fuels: LPG & wood	1,733	2,586	1,797	88	5,115	179	40	3,095
Incinerators, on site	Neg	5	3	Neg	5	Neg	0	5
Mobile sources								
Highway	*	*	*	*	*	*	*	*
Off highway	5,389	4,764	3,990	2,606	13,746	283	40	7,128
Railroads	130	68	90	0	238	82	19	50
Aircraft	275	1,167	1,047	0	1,950	47	0	795
Other								
Forest fire & slash burning	Neg	Neg	642	3	Neg	183	8	219
Agricultural burning	709	116	1,088	Neg	Neg	35	Neg	301
Totals	8,451	8,872	8,898	2,709	21,751	830	109	11,767

* Not updated in this report.

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Table 3 (continued) 1974 CARBON MONOXIDE AREA SOURCE EMISSIONS BY COUNTY

SOURCE CATEGORY	EL PASO	PUEBLO	LARIMER	WELD	GARFIELD	MESA	MOFFAT	RIO BLANCO
Fuel combustion								
Bituminous coal	21	89	17	22	100	128	44	93
Distillate oil	17	8	7	9	2	4	Neg	1
Residual oil	8	5	4	3	Neg	2	Neg	Neg
Natural gas	187	79	64	49	9	36	6	12
Other fuels	3,190	1,426	1,318	1,052	189	656	78	63
Incinerators, on site	1	6	0	6	0	Neg	0	0
Mobile sources								
Highway	259,310	103,331	84,706	99,678	18,943	48,883	10,096	5,035
Off highway	7,063	3,128	2,734	2,683	408	1,475	169	116
Railroads	166	244	164	455	93	109	8	0
Aircraft	6,439	512	16	374	40	174	42	162
Other								
Forest fire & slash burning	1,034	15	534	Neg	204	211	53	71
Agricultural burning	176	1,748	647	5,436	148	407	324	28
Totals	277,612	109,591	90,210	109,761	21,136	52,085	10,820	5,518

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Table 4. 1974 HYDROCARBON AREA SOURCE EMISSIONS BY COUNTY

SOURCE CATEGORY	ADAMS	ARAPAHOE	BOULDER	CLEAR CREEK	DENVER	DOUGLAS	GILPIN	JEFFERSON
Fuel combustion								
Bituminous coal	12	6	15	1	39	3	Neg	10
Distillate oil	9	9	8	1	24	1	Neg	13
Residual oil	4	5	5	Neg	18	Neg	Neg	8
Natural gas	60	53	68	2	214	2	Neg	61
Other fuels	146	209	156	11	419	15	3	269
Incinerators, on site	Neg	1	1	0	2	Neg	0	2
Mobile sources								
Highway	*	*	*	*	*	*	*	*
Off highway	330	292	245	134	844	17	2	437
Railroads	94	49	65	0	172	60	14	36
Aircraft	11	167	41	0	724	2	0	31
Other								
Gasoline evaporation	1,005	859	676	138	3,082	269	37	1,350
Dry cleaning	290	261	210	10	602	20	3	410
Solvent evaporation	185	671	0	8	3,414	0	3	0
Forest fires & slash burning	Neg	Neg	110	1	Neg	33	2	38
Agricultural burning	137	23	201	Neg	Neg	7	Neg	59
Total	2,282	2,605	1,801	306	9,554	429	65	2,725

*Not updated in this report.

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Table 4. (continued. 1974 HYDROCARBON AREA SOURCE EMISSIONS BY COUNTY

SOURCE CATEGORY	LARIMER	WELD	GARFIELD	MESA	MOFFAT	RIO BLANCO		
Fuel combustion								
Bituminous coal	5	7	22	29	10	21		
Distillate oil	5	7	1	3	Neg	Neg		
Residual oil	3	3	Neg	1	Neg	Neg		
Natural gas	26	19	4	15	2	5		
Other fuels	108	88	20	60	6	5		
Incinerators, on site	0	2	2	Neg	0	0		
Mobile sources								
Highway	8,726	10,661	2,058	5,062	1,144	558		
Off highway	168	164	25	90	11	7		
Railroads	118	329	67	79	6	0		
Aircraft	5	16	2	60	2	8		
Other								
Gasoline evaporation	658	802	167	364	86	42		
Dry cleaning	150	140	20	80	10	10		
Solvent evaporation	448	403	26	70	10	9		
Forest fires & slash burning	97	Neg	38	36	9	15		
Agricultural burning	122	1,050	26	76	62	5		
Total	10,639	13,689	2,476	6,010	1,360	686		

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Table 5. 1974 NITROGEN OXIDES AREA SOURCE EMISSIONS BY COUNTY

SOURCE CATEGORY	ADAMS	ARAPAHOE	BOULDER	CLEAR CREEK	DENVER	DOUGLAS	GILPIN	JEFFERSON
Fuel combustion								
Bituminous coal	58	74	111	Neg	441	2	1	151
Distillate oil	160	172	139	8	455	10	2	247
Residual oil	85	94	96	1	352	5	1	154
Natural gas	762	625	908	25	2,840	28	3	672
Other fuels	106	135	106	8	272	16	1	185
Incinerators, on site	1	7	1	1	2	Neg	0	2
Mobile sources								
Highway	*	*	*	*	*	*	*	*
Off highway	911	805	678	98	2,347	41	5	1,216
Railroads	369	194	251	0	677	234	54	143
Aircraft	4	47	11	0	1,037	1	0	9
Other								
Forest fire & slash burning	Neg	Neg	18	Neg	Neg	5	Neg	6
Agricultural burning	14	2	22	Neg	Neg	1	Neg	6
Totals	2,478	2,153	2,348	141	8,422	344	68	2,791

* Not updated in this report.

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1. BITUMINOUS COAL--RESIDENTIAL

PARAMETERS FOR ESTIMATING EMISSIONS

- Residential coal consumption
- Dwelling units using coal

DESCRIPTION OF PROCEDURE

Residential coal consumption was estimated using two methods: retail dealer survey, and degree-day heating equation. A comparison of coal consumption determined by the two methods for each county is shown in Table 1.1.

BASE DATA

Residential coal sales were obtained from telephone conversations with retail coal dealers listed in the yellow pages directory for each county. Additional dealer names were obtained from the local coal dealers initially contacted.

ASSUMPTIONS

1. The eight counties in the Denver AQMA were considered a single distribution area for local coal dealers. Coal was apportioned to each county by the number of dwelling units using coal in each county.
2. Dealer sales are more accurate than consumption calculated by the degree-day heating method.

Table 1.1. RESIDENTIAL COAL CONSUMPTION

(ton/yr)

County	Retail dealer survey	Degree-day heating
Adams	845	1186
Arapahoe	93	137
Boulder	845	1030
Clear Creek	131	205
Denver	1036	1268
Douglas	282	460
Gilpin	0	0
Jefferson	20	153
El Paso	240	256
Pueblo	1704	219
Larimer	230	395
Weld	360	1718
Garfield	2220	3001
Mesa	2793	4552
Moffat	na	971
Rio Blanco	2066	407

3. If a dealer could not be contacted, an average value was assumed for residential coal use based on other local dealers' information. More than half the dealers were contacted in each AQMA.

4. To determine the 1974 dwelling units using coal, the percent decrease from 1960 to 1970 was continued until 1972. Conversations with retail dealers indicated no decrease or a minor increase from 1972 to 1974. Therefore, the 1972 data were used to represent the 1974 dwelling units using coal.

5. The 1974 heating degree-days were used where available. A local 30 year average was used where 1974 heating degree-day data were not available. This average closely approximated 1974 data.

6. Emission factors used were obtained from AP-42, pp 1.1-3.[2]

7. If no dealers existed in a county, the consumption calculated using the degree-day heating equation was used.

EMISSION FACTORS

Residential coal use, hand-fired, lb/ton of coal burned:

Particulate	20
Sulfur dioxide	38(S)
Carbon monoxide	90
Hydrocarbons	20
Nitrogen oxides	3

S = percent sulfur, 0.6% average for Colorado

EXAMPLE CALCULATIONS

The degree-day heating method general equation is:

$$RFC = (DU) \times (DD) \times (HRF) \times (R) \qquad \text{(eq.1)}$$

where RFC = residential fuel consumption, tons

DU = dwelling units

DD = degree-days

HRF = heating requirement factor, tons of coal/dwelling unit/degree-day

R = correction factor for number of rooms/dwelling unit, average number of rooms = 5.0

OTHER INFORMATION

1. Sulfur content used was 0.6 percent.
2. HRF, heating requirement factor, was 0.0012 ton/dwelling unit/degree-day, from APTD-1135.[1]
3. Retail coal dealers contacted were:

Burl Coal & Ice, Denver
Eckolt's Feed & Grain, Denver
Elk Coal Company, Denver
Rio Grande Company, Denver
Stuart, G. H. Company, Denver
Mac's Coal & Wood, Boulder
Nelson Coal Company, Boulder
Adens Coal & Wood, Colorado Springs
C & C Sand Company, Colorado Springs
Young Coal & Feed, Colorado Springs
Mountain Ice & Coal, Pueblo
Somes Bros. Coal & Service, Pueblo
Western Coal Supply & Trucking, Pueblo

Fireplace Coal Company, Ft. Collins
Keyser Coal & Trucking, Greeley
Albert Kirkpatrick, Meeker
Mesa Feed & Farm Supply, Grand Junction
J & J Meney Fuel Company, Carbondale
Spangler & Sons, Silt

Table 1.2. 1974 RESIDENTIAL COAL EMISSIONS

(ton/yr)

County	Partic	SO_2	CO	HC	NO_x
Adams	8		38	8	1
Arapahoe	1		4	1	neg
Boulder	8		38	8	1
Clear Creek	1		6	1	neg
Denver	10		47	10	2
Douglas	3		13	3	neg
Gilpin	0		0	0	0
Jefferson	neg		1	neg	neg
El Paso	2		11		
Pueblo	17		77		
Larimer	2		10	2	
Weld	4		16	4	
Garfield	22	25	100	22	
Mesa	28	32	126	28	
Moffat	10	11	44	10	
Rio Blanco	21	24	93	21	

2. BITUMINOUS COAL
COMMERCIAL-INSTITUTIONAL-INDUSTRIAL

PARAMETER FOR ESTIMATING EMISSIONS

- Commercial-institutional-industrial coal consumption

DESCRIPTION OF PROCEDURE

Commercial-institutional-industrial coal consumption was estimated using two methods: retail dealer survey of coal use in Denver AQMA counties apportioned by county population; apportionment of Bureau of Mines statewide data, retail sales minus residential sales.

BASE DATA

Retail dealer commercial-institutional-industrial sales were obtained by the same method as the residential coal sales. Apportionment of Mineral Industry Survey data as described in AP-1135[1] resulted in negligible commercial-institutional coal usage.

ASSUMPTIONS

1. Dealer sales by county are more accurate than apportioning Mineral Industry Survey data.
2. No coal consumption in the following counties: Clear Creek, Gilpin, Moffat, and Rio Blanco. This assumption

is based on retail dealers' information and is supported by the Bureau of Mines information.

3. Since Denver area dealers did not have detailed sales information by county, the area total was apportioned to each county by population.

EMISSION FACTORS

Emission factors for small spreader stokers were obtained from AP-42, pp 1.1-3,[2] lb/ton of coal burned:

Particulate	2(A)
Sulfur dioxide	38(S)
Carbon monoxide	10
Hydrocarbons	3
Nitrogen oxides	6

A = percent ash content

S = percent sulfur content

OTHER INFORMATION

1. Percent ash content = 8.0 percent
2. Percent sulfur content = 0.6 percent

Table 2.1. BITUMINOUS COAL CONSUMPTION
COMMERCIAL-INSTITUTIONAL-INDUSTRIAL

(ton/yr)

County	Coal consumption
Adams	8,975
Arapahoe	9,836
Boulder	14,629
Clear Creek	16
Denver	58,515
Douglas	282
Gilpin	141
Jefferson	20,251
El Paso	10,275
Pueblo	11,590
Larimer	6,657
Weld	6,281
Garfield	110
Mesa	2,271
Moffat	94
Rio Blanco	47

Table 2.2. 1974 BITUMINOUS COAL EMISSIONS
COMMERCIAL-INSTITUTIONAL-INDUSTRIAL

(ton/yr)

County	Partic	SO_2	CO	HC	NO_x
Adams	466.7		8.9	4.4	67.3
Arapahoe	511.4		9.8	4.9	73.7
Boulder	760.7		14.6	7.3	109.7
Clear Creek	.8		neg	neg	neg
Denver	3042.7		58.5	29.2	438.9
Douglas	14.7		0.3	0.1	2.1
Gilpin	7.3		0.1	0.1	1.1
Jefferson	1053.1		20.3	10.1	151.1
El Paso	534.3		10.3		
Pueblo	602.7		11.6		
Larimer	346.1		6.7	3.3	
Weld	326.6		6.3	3.1	
Garfield	5.7	1.3	0.1	0.1	
Mesa	118.1	25.9	2.3	1.1	
Moffat	4.9	1.1	0.1	neg	
Rio Blanco	2.4	0.5	neg	neg	

3. DISTILLATE OIL

PARAMETER FOR ESTIMATING EMISSIONS

- Residential, commercial-institutional, and industrial distillate oil consumption

DESCRIPTION OF PROCEDURE

The 1973 data on residential distillate oil, as shown in the TRW 1973 Colorado Area Source Emission Inventory,[3] were used. Mineral Industry Survey data for 1973 for commercial-institutional distillate oil were apportioned to the sixteen AQMA counties by population. Current estimates for point source commercial-institutional distillate oil consumption for the sixteen counties was then subtracted to obtain area source fuel usage. This remaining oil was apportioned to each county by population.

Mineral Industry Survey data for 1973 for industrial distillate oil were apportioned to the sixteen AQMA counties by the total number of manufacturing employees in the sixteen counties. Current estimates for industrial point source distillate oil consumption for the sixteen AQMA counties were then subtracted to obtain area source usage. This remaining oil was apportioned to each county by the number of manufacturing employees in each county.

BASE DATA

Residential oil consumption was obtained from the TRW[3] report. Commercial-institutional distillate oil consumption

was obtained from the sum of "distillate-type heating oils," "kerosene used for heating," and "distillate used by the military," from the Mineral Industry Surveys, "1973 Sales of Fuel Oil and Kerosene."[5] The point source fuel oil totals were obtained from Colorado Air Pollution Control Division, air contaminant emission notice files.[6] Population estimates were obtained from the U.S. Department of Commerce, 1973 Population Estimates[7] and projected to 1974.

The state industrial area source distillate oil use was obtained from the sum of "industrial" and "oil companies" categories from the Mineral Industry Survey, "1973 Sales of Fuel Oil and Kerosene." Point source fuel oil use totals were obtained from the Colorado Air Pollution Control Division, air contaminant emission notice files. Manufacturing employee statistics were obtained from Colorado 1973 County Business Patterns.[8]

ASSUMPTIONS

1. The 1973 data are representative of 1974.
2. The 1974 point source distillate oil summary for sixteen AQMA counties better represents the point source fuel usage in the state than the 1972 NEDS point source distillate oil summary.

EMISSION FACTORS

Factors were obtained from AP-42, p 1.3-2,[2] lb/1000 gal of distillate oil burned:

Pollutant	Residential	Commercial-institutional	Industrial
Particulate	10	15	15
Sulfur dioxide	142(S)	142(S)	142(S)
Carbon monoxide	5	4	4
Hydrocarbons	3	3	3
Nitrogen oxides	12	60	60

S = percent sulfur

Table 3.1. DISTILLATE OIL CONSUMPTION

(10^3 gal/yr)

County	Residential	Commercial-institutional	Industrial
Adams	440	4,706	531
Arapahoe	440	4,997	633
Boulder	690	3,546	941
Clear Creek	160	112	1
Denver	1,060	11,170	3,766
Douglas	70	314	18
Gilpin	30	50	9
Jefferson	760	6,778	1,303
El Paso	1,060	6,509	661
Pueblo	350	2,790	746
Larimer	590	2,498	428
Weld	1,310	2,280	404
Garfield	350	381	7
Mesa	500	1,272	146
Moffat	30	151	6
Rio Blanco	100	123	3

Table 3.2. 1974 RESIDENTIAL DISTILLATE OIL EMISSIONS

(ton/yr)

County	Partic	SO_2	CO	HC	NO_x
Adams	2.2		1.1	0.7	2.6
Arapahoe	2.2		1.1	0.7	2.6
Boulder	3.5		1.7	1.0	4.1
Clear Creek	0.8		0.4	0.2	1.0
Denver	5.3		2.7	1.6	6.4
Douglas	0.4		0.2	0.1	0.4
Gilpin	0.2		0.1	neg	0.2
Jefferson	3.8		1.9	1.1	4.6
El Paso	5.3		2.7		
Pueblo	1.8		0.9		
Larimer	3.0		1.5	1.1	
Weld	6.6		3.3	2.5	
Garfield	1.8	6.2	0.9	0.7	
Mesa	2.5	8.9	1.3	1.0	
Moffat	0.2	0.5	0.1	0.1	
Rio Blanco	0.5	1.8	0.3	0.2	

Table 3.3. 1974 COMMERCIAL-INSTITUTIONAL DISTILLATE OIL EMISSIONS

(ton/yr)

County	Partic	SO_2	CO	HC	NO_x
Adams	35.3		9.4	7.1	141.2
Arapahoe	37.5		10.0	7.5	150.0
Boulder	26.6		7.1	5.3	106.4
Clear Creek	0.8		0.2	0.2	3.4
Denver	83.8		22.3	16.8	335.1
Douglas	2.4		0.6	0.5	9.4
Gilpin	0.4		0.1	0.1	1.5
Jefferson	50.8		13.6	10.2	203.3
El Paso	48.8		13.0		
Pueblo	20.9		5.6		
Larimer	18.7		5.0	3.7	
Weld	17.1		4.6	3.4	
Garfield	2.9	16.2	0.8	0.6	
Mesa	9.5	54.2	2.5	1.9	
Moffat	1.1	6.4	0.3	0.2	
Rio Blanco	0.9	5.2	0.2	0.2	

Table 3.4. 1974 INDUSTRIAL DISTILLATE OIL EMISSIONS

(ton/yr)

County	Partic	SO_2	CO	HC	NO_x
Adams	4.0		1.1	0.8	15.9
Arapahoe	4.8		1.3	1.0	19.0
Boulder	7.1		1.9	1.4	28.2
Clear Creek	neg		neg	neg	neg
Denver	28.2		7.5	5.7	113.0
Douglas	0.1		neg	neg	0.5
Gilpin	neg		neg	neg	0.3
Jefferson	9.8		2.6	2.0	39.1
El Paso	5.0		1.3		
Pueblo	5.6		1.5		
Larimer	3.2		0.9	0.6	
Weld	3.0		0.8	0.6	
Garfield	0.1	0.1	neg	neg	
Mesa	1.1	2.6	0.2	0.2	
Moffat	neg	0.1	neg	neg	
Rio Blanco	neg	neg	neg	neg	

4. RESIDUAL OIL

PARAMETER FOR ESTIMATING EMISSIONS

- Commercial-institutional-industrial residual oil consumption

DESCRIPTION OF PROCEDURE

State total commercial-institutional residual fuel oil was apportioned to the sixteen AQMA counties by the population in those counties. The 1974 commercial-institutional residual oil point source summary was subtracted out and the remaining fuel oil was apportioned to each county using the 1974 county population to state population ratio.

State total industrial residual fuel oil was apportioned to the sixteen AQMA counties by the total number of manufacturing employees in those counties. The 1974 industrial residual oil point source summary was subtracted out and the remaining fuel was apportioned to each county using the 1973 county to state manufacturing employee ratio.

BASE DATA

State fuel use totals were obtained from Mineral Industry Surveys, "1973 Sales of Fuel Oil and Kerosene.[5] Census information is the same as that used for distillate oil calculations.[7] Point source fuel oil totals were obtained from Colorado Air Pollution Control Division, air contaminant emission notice files.[6]

ASSUMPTIONS

1. Residential residual oil consumption is negligible.
2. The 1973 data are representative of 1974.
3. The 1974 point source fuel summary for sixteen AQMA counties better represents the point source fuel usage in the state than the 1972 NEDS point source fuel summary.

EMISSION FACTORS

Factors were obtained from AP-42, p 1.3-2,[2] lb/1000 gal burned:

Particulate	23
Sulfur dioxide	157(S)
Carbon monoxide	3
Hydrocarbons	2
Nitrogen oxides	60

S = percent sulfur, 0.9% average for Colorado

Table 4.1. RESIDUAL OIL CONSUMPTION

(10^3 gal/yr)

County	Commercial-institutional	Industrial
Adams	1,753	1,066
Arapahoe	1,862	1,271
Boulder	1,321	1,890
Clear Creek	42	2
Denver	4,162	7,561
Douglas	117	36
Gilpin	19	18
Jefferson	2,525	2,617
El Paso	2,425	1,328
Pueblo	1,039	1,498
Larimer	931	860
Weld	849	812
Garfield	142	14
Mesa	474	293
Moffat	56	12
Rio Blanco	46	6

Table 4.2. 1974 COMMERCIAL-INSTITUTIONAL RESIDUAL OIL EMISSIONS

(ton/yr)

County	Partic	SO_2	CO	HC	NO_x
Adams	20.2		3.5	2.6	52.6
Arapahoe	21.4		3.7	2.8	55.9
Boulder	15.2		2.6	2.0	39.6
Clear Creek	0.5		0.1	0.1	1.3
Denver	47.9		8.3	6.2	124.9
Douglas	1.3		0.2	0.2	3.5
Gilpin	0.2		neg	neg	0.6
Jefferson	29.0		5.1	3.8	75.8
El Paso	27.9		4.9		
Pueblo	11.9		2.1		
Larimer	10.7		1.9	1.4	
Weld	9.8		1.7	1.3	
Garfield	1.6	6.7	0.3	0.2	
Mesa	5.5	22.3	0.9	0.7	
Moffat	0.6	2.6	0.1	0.1	
Rio Blanco	0.5	2.2	0.1	0.1	

Table 4.3. 1974 INDUSTRIAL RESIDUAL OIL EMISSIONS

(ton/yr)

County	Partic	SO_2	CO	HC	NO_x
Adams	12.2		2.1	1.6	32.0
Arapahoe	14.6		2.5	1.9	38.1
Boulder	21.7		3.8	2.8	56.7
Clear Creek	neg		neg	neg	neg
Denver	87.0		15.1	11.3	227.0
Douglas	0.4		0.1	0.1	1.1
Gilpin	0.2		neg	neg	0.5
Jefferson	30.1		5.2	3.9	78.5
El Paso	15.3		2.7		
Pueblo	17.2		3.0		
Larimer	9.9		1.7	1.3	
Weld	9.3		1.6	1.2	
Garfield	0.2	1.0	neg	neg	
Mesa	3.4	20.7	0.6	0.4	
Moffat	0.1	0.8	neg	neg	
Rio Blanco	neg	0.4	neg	neg	

5. NATURAL GAS

PARAMETER FOR ESTIMATING EMISSIONS

- Natural gas sales for residential, commercial-institutional, and industrial use

DESCRIPTION OF PROCEDURE

The point source consumption totals were subtracted from the non-residential consumption, and residential consumption was used as given.

BASE DATA

Natural gas distributors and pipeline companies were contacted for data on residential, commercial-institutional, and industrial consumption by county. Point source consumption was obtained from the Colorado Air Pollution Control Division, air contaminant emission notice files.[6]

ASSUMPTIONS

1. All point sources reported usage.
2. Natural gas losses during transmission were not included in the point source inventory.

EMISSION FACTORS

Factors were obtained from AP-42,[2] lb/10^6 cubic feet of natural gas burned:

Pollutant	Residential	Commercial-institutional and industrial
Particulate	10.0	10.0
Sulfur dioxide	0.6	0.6
Carbon monoxide	20.0	17.0
Hydrocarbons	8.0	3.0
Nitrogen oxides	80.0	120.0

Table 5.1. NATURAL GAS CONSUMPTION

(10^6 cu ft)

County	Residential	Commercial-institutional-industrial
Adams	6,959.6	8,057.1
Arapahoe	8,774.8	4,555.0
Boulder	5,727.6	11,321.8
Clear Creek	216.3	269.4
Denver	18,663.7	34,898.9
Douglas	406.0	198.4
Gilpin	37.8	28.4
Jefferson	12,195.6	3,070.0
El Paso	9,659.2	9,007.6
Pueblo	4,343.1	3,513.0
Larimer	3,890.9	2,486.8
Weld	3,236.4	1,618.5
Garfield	545.9	389.2
Mesa	2,136.3	1,468.4
Moffat	249.0	304.5
Rio Blanco	56.3	1,116.1

Table 5.2. 1974 RESIDENTIAL NATURAL GAS EMISSIONS

(ton/yr)

County	Partic	SO_2	CO	HC	NO_x
Adams	34.8		69.6	27.8	278.4
Arapahoe	43.9		87.8	35.1	351.2
Boulder	28.6		57.2	22.9	228.8
Clear Creek	1.1		2.2	0.9	8.8
Denver	93.3		186.6	74.6	746.4
Douglas	2.0		4.0	1.6	16.0
Gilpin	0.2		0.4	0.2	1.6
Jefferson	61.0		122.0	48.8	488.0
El Paso	48.3		96.6		
Pueblo	21.7		43.4		
Larimer	19.5		39.0	15.6	
Weld	16.2		32.4	12.9	
Garfield	2.7	0.2	5.5	2.2	
Mesa	10.7	0.6	21.4	8.5	
Moffat	1.2	0.1	2.5	1.0	
Rio Blanco	0.3	neg	0.6	0.2	

Table 5.3. 1974 COMMERCIAL-INSTITUTIONAL-INDUSTRIAL NATURAL GAS EMISSIONS

(ton/yr)

County	Partic	SO_2	CO	HC	NO_x
Adams	40.3		80.6	32.2	483.4
Arapahoe	22.8		45.6	18.2	273.3
Boulder	56.6		113.2	45.3	679.3
Clear Creek	1.3		2.7	1.1	16.2
Denver	174.5		349.0	139.6	2093.9
Douglas	1.0		2.0	0.8	11.9
Gilpin	0.1		0.3	0.1	1.7
Jefferson	15.4		3.1	12.3	184.2
El Paso	45.0		90.1		
Pueblo	17.6		35.1		
Larimer	12.4		24.9	9.9	
Weld	8.1		16.2	6.5	
Garfield	1.9	0.1	3.9	1.6	
Mesa	7.3	0.4	14.7	6.0	
Moffat	1.5	0.1	3.0	1.2	
Rio Blanco	5.6	0.3	11.2	4.5	

6. LIQUEFIED PETROLEUM GAS

PARAMETER FOR ESTIMATING EMISSIONS

- Liquefied petroleum gas (LPG) consumption

DESCRIPTION OF PROCEDURE

Total LPG consumption was divided into residential and commercial-institutional consumption by the ratio of the state residential natural gas consumption to state commercial-institutional natural gas consumption. The residential LPG usage was apportioned to each county by the number of dwelling units that use LPG for heating. The commercial-institutional consumption was apportioned to each county by county population. The industrial LPG consumption (available as a separate fuel use summary) for the sixteen AQMA counties was apportioned to those counties by the total number of manufacturing employees in the sixteen counties. The point source LPG consumption was subtracted out and the remainder was apportioned to each county using the number of manufacturing employees.

BASE DATA

1. Mineral Industry Surveys, "1973 Sales of LPG and Ethane."[9]
2. The 1973 County Business Patterns.[8]

3. Colorado Air Pollution Control Division, air contaminant emission notice files.[6]

ASSUMPTIONS

1. The LPG usage follows patterns similar to natural gas.

2. The 1973 information is representative of 1974.

EMISSION FACTORS

Factors were obtained from AP-42, p 1.5-2,[2] lb/1000 gal burned:

Pollutant	Residential	Commercial	Industrial
Particulate	1.850	1.850	1.750
Sulfur dioxide	0.014	0.014	0.014
Carbon monoxide	1.950	1.950	1.550
Hydrocarbons	0.750	0.750	0.300
Nitrogen oxides	7.500	11.500	11.600

OTHER INFORMATION

1. Industrial consumption is the sum of industrial and miscellaneous categories from the Mineral Industry Surveys.[9]

2. Sulfur content is 0.16 grains per 100 cf vapor.

3. No commercial-institutional LPG point sources.

Table 6.1. LIQUEFIED PETROLEUM GAS CONSUMPTION

(10^3 gal/yr)

County	LPG consumption
Adams	9,536
Arapahoe	8,496
Boulder	8,626
Clear Creek	847
Denver	17,955
Douglas	2,526
Gilpin	308
Jefferson	15,105
El Paso	14,331
Pueblo	7,767
Larimer	8,256
Weld	14,392
Garfield	2,345
Mesa	3,987
Moffat	559
Rio Blanco	485

Table 6.2. 1974 LIQUEFIED PETROLEUM GAS EMISSIONS

(ton/yr)

County	Partic	SO_2	CO	HC	NO_x
Adams	9		9	4	36
Arapahoe	8		8	3	32
Boulder	8		8	3	32
Clear Creek	1		1	neg	3
Denver	17		18	7	67
Douglas	2		2	1	9
Gilpin	neg		neg	neg	1
Jefferson	14		15	6	57
El Paso	13		14		
Pueblo	7		8		
Larimer	8		8	3	
Weld	13		14	5	
Garfield	2	neg	2	1	
Mesa	4	neg	4	1	
Moffat	1	neg	1	neg	
Rio Blanco	neg	neg	neg	neg	

7. WOOD

PARAMETER FOR ESTIMATING EMISSIONS

- Tons of wood burned in stoves
- Tons of wood burned in fireplaces

DESCRIPTION OF PROCEDURE

The residential wood consumption for stoves was multiplied by appropriate emission factors.

Single family and multifamily dwelling units (DU) were used to determine the number of fireplaces in each county. Factors of 1.6 cords of wood burned per year[40] (obtained in a Reno, Nevada survey) and 3000 pounds per cord of wood[41] (average of hardwood and pine) were used to estimate an average fireplace wood consumption of 4800 pounds per year. This consumption rate was compared to a similar consumption rate developed in a trial air quality maintenance plan for Eagle County.[42] The Eagle County study showed 4368 pounds per year (60 lb/day x 182 day/yr x 40 percent of the time). The 4800 pounds per year factor was used.

Number of fireplaces was multiplied by the wood consumption rate and by 0.80 (correction for fireplaces not in use) to obtain total annual wood consumption by county. These data are shown in Table 7.1. Fireplace wood consumption was multiplied by the appropriate emission factor.

Table 7.1. 1974 FIREPLACE WOOD CONSUMPTION

County	Single family DU No.	Single family DU % Fireplaces	Multifamily DU No.	Multifamily DU % Fireplaces	Total no. fireplaces	Annual wood consumption, ton/yr
Adams	47,182	64	19,542	29	35,864	68,859
Arapahoe	55,913	68	27,037	58	53,702	103,108
Boulder	38,210	53	19,853	69	37,086	71,205
Clear Creek	1,994	65[a]	949	49[a]	1,761	3,381
Denver	118,951	64	103,323	29	106,092	203,697
Douglas	4,542	68	1,052	58	3,699	7,102
Gilpin	904	65[a]	493	49[a]	829	1,592
Jefferson	77,192	66	29,273	44	63,827	122,548
El Paso	64,450	69	40,058	54	66,102	126,916
Pueblo	33,828	69[b]	11,180	54[b]	29,378	56,406
Larimer	28,484	53[c]	17,678	69[c]	27,294	52,404
Weld	24,701	53[c]	12,355	69[c]	21,616	41,502
Garfield	4,264	65[a]	2,149	49[a]	3,825	7,344
Mesa	16,976	65[a]	4,956	49[a]	13,465	25,852
Moffat	1,959	65[a]	684	49[a]	1,609	3,090
Rio Blanco	1,549	65[a]	607	49[a]	1,304	2,504

[a] Assumed average percent fireplaces.

[b] Assumed El Paso percent fireplaces.

[c] Assumed Boulder percent fireplaces.

BASE DATA

The residential wood consumption for stoves by county was obtained from the TRW Colorado 1973 Area Source Emission Inventory.[3]

The number of single and multifamily dwelling units were obtained from the Colorado Division of Planning, Demographic Section.[43] The percent fireplaces for the Denver area, Boulder, and Colorado Springs (averages were used for other counties where data were unavailable) were obtained from a residential sales survey.[44]

ASSUMPTIONS

1. No significant change in residential wood consumption for stoves has occurred from 1972 to 1974.
2. All commercial, institutional, and industrial wood burning is included in the Colorado point source emission inventory.
3. The Residential Sales Survey (a small sample of houses and condominiums built from 1965 to 1975) was representative of the distribution of fireplaces in all houses and condominiums.
4. Lodge, motel, and restaurant fireplaces were assumed negligible.
5. Percent fireplaces in Boulder were used to represent Larimer and Weld Counties.
6. Percent fireplaces in Colorado Springs (El Paso) were used to represent Pueblo County.
7. Clear Creek, Gilpin, and Western Slope Counties were assumed to have an average percent fireplaces of the Front Range Counties.

EMISSION FACTORS

Open burning of wood refuse emission factors were used for fireplaces, and wood waste in boiler emission factors were used for stoves. Factors were obtained from AP-42,[2] and are shown in Table 7.2.

Table 7.2. WOODBURNING EMISSION FACTORS

(lb/ton burned)

	Partic	SO_2	CO	HC	NO_x
Open burning of wood refuse	17	neg	50	4	2
Wood waste in boilers	5-15	1.5	2-60 (avg 31)	2-70 (avg 36)	10
Forest wildfires	17	neg	140	24	4

Table 7.3. 1974 RESIDENTIAL WOOD CONSUMPTION AND EMISSIONS FOR STOVES

(ton/yr)

County	Consumption, tons	Partic	SO_2	CO	HC	NO_x
Adams	200	1		3.1	3.6	1.0
Arapahoe	0	0		0	0	0
Boulder	600	6		9.3	10.8	3.0
Clear Creek	200	2		3.1	3.6	2.0
Denver	300	3		4.7	5.4	1.5
Douglas	0	0		0	0	0
Gilpin	0	0		0	0	0
Jefferson	1000	10		15.5	18.0	5.0
El Paso	200	2		3.1		
Pueblo	500	5		7.8		
Larimer	0	0		0	0	
Weld	0	0		0	0	
Garfield	200	2	0.2	3.1	3.6	
Mesa	400	4	0.3	6.2	7.2	
Moffat	0	0	0	0	0	
Rio Blanco	0	0	0	0	0	

Table 7.4. 1974 FIREPLACE EMISSIONS FROM WOODBURNING

(ton/yr)

County	Partic	SO_2	CO	HC	NO_x
Adams	585		1721	138	69
Arapahoe	876		2578	206	103
Boulder	605		1780	142	71
Clear Creek	29		84	7	3
Denver	1731		5092	407	203
Douglas	60		177	14	7
Gilpin	14		40	3	1
Jefferson	1042		3064	245	123
El Paso	1079		3173		
Pueblo	479		1410		
Larimer	445		1310		
Weld	353		1038		
Garfield	62	neg	184	15	
Mesa	220	neg	646	52	
Moffat	26	neg	77	6	
Rio Blanco	21	neg	63	5	

8. OPEN REFUSE BURNING

Due to regulations enforced by the State of Colorado Air Pollution Control Division, it is estimated that emissions from municipal open burning are negligible. The only potential source of refuse burning is residential refuse burned by people living more than two miles from an incorporated municipality (with population greater than 500) or living in remote parts of the state designated in the state regulations. Conversations with APCD staff indicated that unincorporated towns and villages also normally observe this regulation. Therefore, rural population is the only potential source of refuse burning. The emissions resulting from this would be negligible in the AQMA counties.

9. AGRICULTURAL BURNING

PARAMETERS FOR ESTIMATING EMISSIONS

- Field acres burned
- Miles of irrigation ditches burned
- Miles of fence rows and roadside ditches burned

DESCRIPTION OF PROCEDURE

Field acres were converted to tons of vegetation. Miles of ditches and fence rows were converted to acres and then to tons of vegetation. Emission factors were applied to the total tons of vegetation.

BASE DATA

Field acres and ditch and row miles burned were obtained from the 1972-73 agricultural open burning file at the Colorado Air Pollution Control Division.[10] Average values for acres per mile and tons per acre of irrigation ditch were obtained from unpublished test results by Dr. Ellis Darley of the University of California, Riverside.[11]

ASSUMPTIONS

1. Main and lateral irrigation ditches are 8 feet wide.

2. A fence row is 1 foot wide.

3. A roadside ditch is 2 feet wide.

4. Three tons per acre is the average amount of vegetation in agricultural field burning.

5. Piles of branches, trees, hay, twines, and riverbed burning were neglected.

6. Sulfur dioxide emissions are negligible.

EMISSION FACTORS

Factors are from AP-42,[2] lb/ton of vegetation burned:

Pollutant	Field acres, fence rows, and roadside ditches	Irrigation ditches
Particulate	17	15.5
Carbon monoxide	100	103.5
Hydrocarbons	20	12.0
Nitrogen oxides	2	2.0

EXAMPLE CALCULATIONS

(Miles of ditch or fence) x (Acres/mile factor) x (3 ton/acre) = tons of vegetation burned/yr

Table 9.1. IRRIGATION DITCH DATA FOR CALCULATION OF TONS OF VEGETATION BURNED

County	Field acres	Irrigation ditches Main miles	Lateral miles	Fence miles	Roadside miles
Adams	1814.8	121.1	246.9	272.8	87.4
Arapahoe	278.0	18.5	18.0	44.3	24.6
Boulder	2932.5	550.7	639.2	308.9	153.7
Clear Creek	neg	neg	neg	neg	neg
Denver	neg	neg	neg	neg	neg
Douglas	102.0	6.3	8.5	11.8	6.5
Gilpin	neg	neg	neg	neg	neg
Jefferson	1673.0	20.3	93.8	21.0	11.3
El Paso	306.0	16.8	34.5	93.0	17.0
Pueblo	6235.4	449.6	438.4	422.6	245.9
Larimer	1597.5	261.6	335.1	202.5	119.0
Weld	17596.2	1160.1	1710.1	1494.9	931.0
Garfield	307.5	113.9	132.2	37.9	30.6
Mesa	982.5	167.1	224.7	127.7	75.8
Moffat	1701.0	68.5	106.8	27.5	14.7
Rio Blanco	149.0	11.1	9.3	1.5	0.5

Table 9.2 1974 BURNING OF FIELDS, FENCE ROWS, AND ROADSIDE DITCHES EMISSIONS

(ton/yr)

County	Partic	CO	HC	NO_x
Adams	111	652	130	13
Arapahoe	19	110	22	2
Boulder	153	903	180	18
Clear Creek	0	0	0	0
Denver	0	0	0	0
Douglas	6	33	7	1
Gilpin	0	0	0	0
Jefferson	48	283	57	6
El Paso	29	168		
Pueblo	274	1610		
Larimer	94	554	111	
Weld	849	4990	998	
Garfield	19	110	22	
Mesa	59	346	69	
Moffat	51	297	59	
Rio Blanco	4	24	5	

Table 9.3 1974 IRRIGATION DITCH BURNING EMISSIONS

(ton/yr)

County	Partic	CO	HC	NO_x
Adams	8.6	57.1	6.6	1.1
Arapahoe	0.9	5.7	0.7	0.1
Boulder	27.7	184.7	21.4	3.6
Clear Creek				
Denver				
Douglas	0.4	2.3	0.3	0.1
Gilpin				
Jefferson	2.7	17.7	2.1	0.3
El Paso	1.2	8.0		
Pueblo	20.6	137.9		
Larimer	13.9	92.7	10.7	
Weld	66.7	445.6	51.7	
Garfield	5.7	38.2	4.4	
Mesa	9.1	60.8	7.1	
Moffat	4.1	27.2	3.2	
Rio Blanco	0.5	3.2	0.4	

10. SLASH BURNING

PARAMETER FOR ESTIMATING EMISSIONS

- Acreage on which slash burning occurs

DESCRIPTION OF PROCEDURE

Data on acres of slash burning were collected by county for 1974. In addition, the U.S. Forest Service estimated tons of slash burned and slash acreage for 1975. The calculated values for tons per acre of slash for 1975 were applied to the 1974 slash acreage data to convert it to tonnage data. Tons burned for each county were summed and the appropriate emission factor was applied.

BASE DATA

Information on acres and tons burned was obtained from:

1. Colorado Air Pollution Control Division, application for open burning permit files.[10]
2. U. S. Forest Service, open burning records.[12]

ASSUMPTIONS

1. Average tons per acre of slash did not change from 1974 to 1975.
2. Sulfur dioxide emissions are negligible.

EMISSION FACTORS

Factors for slash burning were obtained from AP-42,[2] lb/ton burned:

Particulate	17
Carbon monoxide	60
Hydrocarbons	20
Nitrogen oxides	2

Table 10.1. 1974 SLASH BURNING EMISSIONS

County	Consumption, tons	Partic	CO	HC	NO_x
Adams					
Arapahoe					
Boulder					
Clear Creek	60.0	0.5	1.8	0.6	0.1
Denver					
Douglas	240.0	2.0	7.2	2.4	0.2
Gilpin	20.0	0.2	0.6	0.2	neg
Jefferson	175.0	1.5	5.3	1.7	0.2
El Paso					
Pueblo					
Larimer	1087.7	9.2	32.6	10.9	
Weld					
Garfield	603.7	5.1	18.1	6.0	
Mesa					
Moffat					
Rio Blanco	504.0	4.3	15.1	5.0	

11. FOREST FIRES

PARAMETERS FOR ESTIMATING EMISSIONS

- Acres of forest burned
- Average timber density per acre

DESCRIPTION OF PROCEDURE

Acres of each type of vegetation burned were converted to tons burned by the appropriate timber density factors. Emission factors were then applied.

BASE DATA

1. Tons per acre conversion factors were obtained from the U.S. Forest Service, Rocky Mountain Regional Office[13] and from Development of Emission Factors for Estimating Emissions from Forest Fires.[14]
2. Acres burned on state land were obtained from the Colorado State Forest Service.[15]
3. Acres burned on federal land were obtained from the U.S. Forest Service, Rocky Mountain Regional Office.[16]

ASSUMPTIONS

1. All types of vegetation have the same emission factors.

2. Assume 100 ton/acre for "timber" acres. Messrs. Dick Stillman and Jerry Wadlow, National Forest Service, Regional Office, Denver suggested 100 to 200 ton/acre.

3. Sulfur dioxide emissions are negligible.

EMISSION FACTORS

Factors for forest fires were obtained from AP-42,[2] lb/ton burned:

Particulate	17
Carbon monoxide	140
Hydrocarbons	24
Nitrogen oxides	4

OTHER INFORMATION

Factors for converting from acres to tons of vegetation:

Vegetation type	Ton/acre
Grass	3
Pinyon juniper	5
Sage brush	6
Oak brush	25
Timber	100
Other	20

Table 11.1. FOREST FIRE DATA FOR CALCULATION OF TONS OF VEGETATION BURNED

County	Acres of vegetation						Total vegetation burned (ton/yr)
	Grass	Pinyon juniper	Sage brush	Oak brush	Timber	Other	
Adams	neg	neg	neg	neg	neg	neg	neg
Arapahoe	neg	neg	neg	neg	neg	neg	neg
Boulder	71.2	neg	neg	neg	33.1	282.2	9168.0
Clear Creek	3.5					0.4	18.5
Denver	neg	neg	neg	neg	neg	neg	neg
Douglas	50.5	neg	neg	neg	21.3	11.8	2514.0
Gilpin	0.5	neg	neg	neg	1.0	0.6	115.0
Jefferson	98.8	neg	neg	neg	5.2	111.5	3045.0
El Paso	1724.5	2.0	neg	neg	12.1	418.5	14765.0
Pueblo	30.0	neg	0.5	neg	neg	6.1	215.0
Larimer	73.6	neg	2.9	neg	59.3	50.1	7167.0
Weld	95.3	neg	neg	neg	neg	neg	neg
Garfield	94.5	16.0	24.5		3.1	92.0	2662.0
Mesa	neg	neg	neg	neg	21.1	31.5	3028.0
Moffat	neg	neg	neg	neg	7.5	neg	750.0
Rio Blanco	13.0	23.5	neg	13.3	3.0	neg	792.0

Table 11.2. 1974 FOREST FIRE EMISSIONS

(ton/yr)

County	Partic	CO	HC	NO_x
Adams	neg	neg	neg	neg
Arapahoe	neg	neg	neg	neg
Boulder	77.9	641.8	110.0	18.3
Clear Creek	0.2	1.3	0.2	neg
Denver	neg	neg	neg	neg
Douglas	21.4	176.0	30.2	5.0
Gilpin	1.0	8.1	1.4	0.2
Jefferson	25.9	213.2	36.5	6.1
El Paso	125.5	1033.6		
Pueblo	1.8	15.1		
Larimer	60.9	501.7	86.0	
Weld	neg	neg	neg	
Garfield	22.6	186.3	31.9	
Mesa	25.7	211.0	36.3	
Moffat	6.4	52.5	9.0	
Rio Blanco	6.7	55.4	9.5	

12. HIGHWAY MOBILE SOURCES

PARAMETERS FOR ESTIMATING EMISSIONS

- Vehicle miles traveled
- Vehicle age distribution
- Ambient temperature
- Percent of vehicles operating with a cold engine
- Altitude
- Average vehicle speed

DESCRIPTION OF PROCEDURE

Traffic counts for each road type for 1972 were projected to 1975 for all AQMA's except the Denver AQMA. Vehicle miles traveled (VMT) were projected for light duty passenger cars, light duty gasoline trucks, heavy duty gasoline trucks, and heavy duty diesel trucks. Emission factors were calculated according to the procedure described in AP-42, Supplement 5.[17] Appropriate emission factors were multiplied by VMT for each vehicle type to obtain highway emissions.

The EPA Region VIII staff are planning to calculate motor vehicle emissions for the Denver AQMA.

BASE DATA

1. The VMT and average vehicle speeds were obtained from the Colorado Division of Highways, Department of Planning and Research. The following documents were used:

Colorado 1972 Traffic Volume Study;[18] Colorado 1974 Traffic Volume Study;[19] Colorado 1974 State Highway System Route Description and Mileage Statistics;[20] and unpublished 1968 and 1990 Functional Classification.[21]

2. Trial Air Quality Maintenance Plan for Denver,[22] prepared by GCA for EPA, was used to obtain vehicle age distribution and weighted annual travel.

ASSUMPTIONS

1. The 1975 projected VMT are representative of 1974.
2. The heavy duty gasoline/diesel split is as follows: state and urban roads--60 percent gasoline and 40 percent diesel; county roads--75 percent gasoline and 25 percent diesel.
3. Mean annual temperature = 48° F; 20 percent cold start and 80 percent hot start; high altitude emission factors.

EMISSION FACTORS

The 1975 composite emission factors for each vehicle type and for the projection years 1980 and 1985 are summarized in a report from Alan M. Voorhees, dated August 29, 1975.[23] Readers are referred to that report for the emission factor values.

Table 12.1. 1974 DAILY VEHICLE MILES TRAVELED (VMT)

County	State highway	County roads	Urban roads	Total
El Paso	889,600	189,100	3,805,100	4,883,800
Pueblo	803,800	54,400	1,216,500	2,074,700
Larimer	1,059,400	236,200	615,300	1,910,900
Weld	1,628,100	230,400	470,800	2,329,300
Garfield	445,100	38,900		484,000
Mesa	408,200	94,500	553,700	1,056,400
Moffat	195,000	54,500		249,500
Rio Blanco	91,900	31,200		123,100

Table 12.2. 1974 HIGHWAY MOBILE SOURCE EMISSIONS

(ton/yr)

County	Partic	SO_2	CO	HC
El Paso	1102.7		259310.0	
Pueblo	481.2		103330.7	
Larimer	451.8		84705.6	8726.4
Weld	584.5		99677.9	10660.9
Garfield	118.1	51.6	18943.4	2057.8
Mesa	254.2	106.3	48882.7	5062.2
Moffat	63.0	30.1	10096.2	1143.5
Rio Blanco	30.6	13.8	5035.0	558.3

13. OFF-HIGHWAY FUEL USE

PARAMETERS FOR ESTIMATING EMISSIONS

- Gallons of gasoline consumed by off-highway equipment (farm tractors, lawnmowers, snowmobiles, self-powered farm equipment, electric generator units, etc.
- Gallons of diesel fuel consumed by off-highway equipment

DESCRIPTION OF PROCEDURE

Data on off-highway gasoline and diesel fuel consumption by county were multiplied by emission factors that were obtained by averaging the published factors in AP-42[2] for all equipment considered to be in the off-highway category. This method of determining an appropriate emission factor is reasonably accurate because the range in emission rates for different types of equipment is relatively small.

BASE DATA

Fuel consumption estimates for 1973 were taken from the TRW[3] report.

EMISSION FACTORS

The emission factor for gasoline-powered off-highway equipment was based on the following types of vehicles: farm tractors, other farm equipment, lawn and garden equipment, wheeled tractors, motor graders, loaders, rollers, industrial engines, and miscellaneous. Diesel-powered equipment included farm tractors, other farm equipment, other tractors, dozers, scrapers, graders, loaders, off-highway trucks, rollers, and miscellaneous. The range of emission factors for these different vehicles and the averages are summarized below:

Equipment	Emission factor, lb/1000 gal				
	Partic	SO_2	CO	HC	NO_x
Gasoline-powered:					
Range	6.1-8.3	5.2-5.4	3260-4100	133-328	45-151
Average	6.9	5.3	3730	189	103
Diesel-powered:					
Range	14.8-51.3	31.1-31.2	66-161	17-61	240-524
Average	30.2	31.2	101	34	399

Table 13.1. OFF-HIGHWAY FUEL CONSUMPTION

(10^3 gal/yr)

County	Off-highway gasoline	Off-highway diesel
Adams	2786	385
Arapahoe	2463	340
Boulder	2062	287
Clear Creek	1394	13
Denver	7103	994
Douglas	147	17
Gilpin	21	2
Jefferson	3683	515
El Paso	3660	470
Pueblo	1617	224
Larimer	1413	197
Weld	1388	188
Garfield	211	29
Mesa	763	103
Moffat	87	13
Rio Blanco	60	8

Table 13.2. EMISSIONS FROM OFF-HIGHWAY FUEL USE

(ton/yr)

County	Partic	SO_2	CO	HC	NO_x
Adams	68		5389	330	911
Arapahoe	60		4764	292	804
Boulder	50		3990	245	678
Clear Creek	7		2606	134	98
Denver	174		13746	843	2347
Douglas	3		283	17	41
Gilpin	neg		40	2	5
Jefferson	90		7127	437	1216
El Paso	84		7062		
Pueblo	39		3128		
Larimer	35		2734	168	
Weld	33		2683	164	
Garfield	5	5	408	25	
Mesa	18	18	1475	90	
Moffat	2	2	169	10	
Rio Blanco	1	1	116	7	

14. AIRCRAFT

PARAMETER FOR ESTIMATING EMISSIONS

- Landing-takeoff cycles by aircraft type

DESCRIPTION OF PROCEDURE

Airport operation totals were obtained from FAA records. Aircraft types (e.g., air carrier, general aviation) were broken down into more specific types using fleet mix information for each airport. Emission factors per engine for each type of airplane were applied and multiplied by the number of engines.

BASE DATA

Aircraft operations by airport were obtained from:

1. The 1974 FAA Air Traffic Activity.[24]
2. FAA Master Record, FAA Regional Office, Denver.[25]
3. The 1973 Military Air Traffic Activity Report.[26]

Fleet mix information was obtained from:

1. Official Airline Guide, November, 1974[27] (airport schedules were broken down into frequency factors).
2. Airport Master Plans for Peterson Field, Colorado Springs,[28] and Stapleton International;[29] unpublished Airport Master Plans for Walker Field, Grand Junction,[30] Fort Collins-Loveland,[31] and Garfield County.[32]
3. Three telephone conversations with military airport facilities.[33]

ASSUMPTIONS

1. Fleet mix for general aviation operations were obtained from national averages for all airports except Denver AQMA airports.

2. Air taxis were all assumed to be twin turbine engine aircraft.

Table 14.1. FLEET MIX FOR AIRCRAFT BY AIRCRAFT TYPE

(percent)

FLEET MIX FOR AIR CARRIER

Airport	Jumbo jets	Long range	Medium range	Turbo-props
Stapleton International	4.1	1.8	50.9	43.2
Peterson Field			76.3	23.7
Walker Field		8.7	39.1	52.8
Pueblo			10.0	90.0

FLEET MIX FOR GENERAL AVIATION

Area	Single engine piston	Multi-engine piston	Turbine	Other
Denver AQMA	76.0	20.0	4.0	
El Paso & Pueblo AQMA	82.0	12.5	2.2	3.2
Larimer-Weld AQMA	82.0	12.5	2.2	3.2
Oil Shale AQMA	82.0	12.5	2.2	3.2
Military Airport-Civil Operations	90.0	10.0		

FLEET MIX FOR MILITARY AVIATION

Airport	Jet		Prop		Helicopter	
	Single	Multi	Single	Twin	Single	Twin
Peterson Field	90	10				
Pueblo Municipal	90	10				
Stapleton Internat'l	90	10				
Walker Field	90	10				
Butts AAF			15	15	64	16
Buckley AFB	85	10		5	5	
Air Force Academy	All single engine military piston					

Table 14.2. 1974 LANDING-TAKEOFF CYCLES

Airport	Air carrier	Air taxi	Military	General aviation
Sky Ranch	-	300	12	37,500
Arapahoe City Airport	-	150	40	105,000
Buckley Air National Guard	-	-	19,762	21,106
Columbine Airport	-	-	25	10,000
Boulder Municipal	-	100	50	99,800
Longmont Municipal	-	100	500	45,500
Stapleton International	99,027	8,779	749	92,146
Littleton	-	-	-	6,500
Jefferson City Municipal	-	55	332	110,339
Peterson Field	9,213	318	25,144	9,213
Butts AAF	-	-	58,187	28,577
Air Force Academy	-	-	51,221	7,784
Pueblo Memorial	2,552	382	23,844	41,532
Fort Collins-Loveland	-	500	50	17,500
Weld City Municipal	-	1,250	100	53,988
Flying D Ranch	-	-	-	1,500
Garfield City Airport	-	250	5	4,050
Glenwood Springs Municipal	-	125	-	2,000
Walker Field	4,163	2,311	221	24,639
Craig-Moffat	-	400	5	6,000
Rangely	-	50	-	16,500
Meeker	-	500	-	7,000

Table 14.3. 1974 AIRCRAFT EMISSIONS

(ton/yr)

County	Airport	Partic	SO_2	CO	HC	NO_x
Adams	Sky Ranch	0.9		275.4	11.1	3.6
Arapahoe	Arapahoe City	2.2		755.7	29.7	8.9
	Buckley ANG	4.1		338.4	135.0	38.2
	Columbine Airport	0.1		73.2	2.4	0.1
	Total	6.4		1167.3	167.1	47.2
Boulder	Boulder Municipal	2.0		722.7	28.0	7.9
	Longmont Municipal	0.9		324.7	12.6	3.5
	Total	2.9		1047.4	40.6	11.4
Denver	Stapleton Internt'l	91.5		1949.9	724.4	1037.1
Douglas	Littleton	0.1		46.8	1.8	0.5
Jefferson	Jefferson City	2.2		795.2	30.7	8.6
El Paso	Peterson Field	12.1		740.5		
	Butts AAF	10.5		1213.1		
	Air Force Academy	8.3		4485.5		
	Total	30.9		6439.1		
Pueblo	Pueblo Memorial	7.9		511.9		
Larimer	Fort Collins-Loveland	0.5		15.5	5.3	
Weld	Weld City Municipal	1.3		362.9	15.6	
	Flying D Ranch	neg		10.9	0.4	
	Total	1.3		373.8	16.0	
Garfield	Garfield City	0.1	0.1	27.5	1.3	
	Glenwood Springs	neg	0.1	13.6	0.6	
	Total	0.1	0.2	41.1	1.9	
Mesa	Walker Field	1.4	4.8	173.6	59.9	
Moffat	Craig-Moffat	0.3	0.2	42.0	2.3	
Rio Blanco	Rangely	0.3	0.2	108.8	4.0	
	Meeker	0.5	0.4	52.7	3.9	
	Total	0.8	0.6	161.5	7.9	

15. RAILROADS

PARAMETER FOR ESTIMATING EMISSIONS

- Gallons of diesel fuel used by locomotives

DESCRIPTION OF PROCEDURE

Statewide diesel fuel used by locomotives was apportioned to each county by the number of miles of track in the county.

BASE DATA

The TRW[3] survey of railroads and the Rand McNally Handy Railroad Atlas of the United States[34] were used to determine miles of track. Diesel fuel data were obtained from Mineral Industry Surveys, "1973 Sales of Fuel Oil and Kerosene."[5]

ASSUMPTIONS

Residual and distillate fuel oils used by railroads were totaled and used as diesel fuel consumption.

EMISSION FACTORS

Factors were obtained from AP-42,[2] lb/1000 gal:

Pollutant	Average locomotive emissions
Particulate	25
Sulfur dioxide	57
Carbon monoxide	130
Hydrocarbons	94
Nitrogen oxides	370

Table 15.1. 1974 RAILROAD FUEL OIL CONSUMPTION AND EMISSIONS

(ton/yr)

County	Consumption, 1000 gal	Partic	SO_2	CO	HC	NO_x
Adams	1993.6	24.9		129.6	93.7	368.8
Arapahoe	1047.6	13.1		68.1	49.2	193.8
Boulder	1389.5	17.4		90.3	65.3	257.1
Clear Creek	0	0		0	0	0
Denver	3658.9	45.7		237.8	172.0	676.9
Douglas	1276.1	15.8		82.4	59.6	234.4
Gilpin	291.1	3.6		18.9	13.7	53.9
Jefferson	771.4	9.6		50.1	36.3	142.7
El Paso	2545.4	31.8		165.5		
Pueblo	3748.8	46.8		243.7		
Larimer	2517.1	31.5		163.6	118.3	
Weld	6991.9	87.4		454.5	328.6	
Garfield	1425.3	17.8	40.6	92.6	67.0	
Mesa	1683.3	21.1	48.0	109.4	79.1	
Moffat	126.9	1.6	3.6	8.2	6.0	
Rio Blanco	0	0	0	0	0	

16. INDUSTRIAL PROCESSES--STATIONARY

PARAMETER FOR ESTIMATING EMISSIONS

- Individual source emission estimates from ACEN forms

DESCRIPTION OF PROCEDURE

Point sources with emissions at less than five tons per year were not included in the point source inventory. These sources contribute only a small percentage of the total point source emissions and have, therefore, been treated as area sources. The sources considered in this section are only those with process emissions; fuel combustion emissions from small point sources are assumed to have been included in the sections for sources of fuel combustion (e.g. Distillate Oil--Industrial). The identified process emissions included only particulates. Emissions of other pollutants were all either from fuel combustion or evaporative losses.

BASE DATA

All data used to estimate emissions from these sources were obtained from the Colorado Air Pollution Control Division, air contaminant emission notice files.[6]

EMISSION FACTORS

Factors were obtained from AP-42[2] or from other data provided by the sources on their ACEN forms.

Table 16.1. 1974 STATIONARY INDUSTRIAL PROCESS EMISSIONS

(ton/yr)

County	Particulate
Adams	61
Arapahoe	18
Boulder	7
Clear Creek	0
Denver	2
Douglas	6
Gilpin	0
Jefferson	6
El Paso	5
Pueblo	12
Larimer	5
Weld	14
Garfield	0
Mesa	9
Moffat	0
Rio Blanco	0

17. INDUSTRIAL PROCESSES--PORTABLE

PARAMETER FOR ESTIMATING EMISSIONS

- Process data for each concrete or asphalt batch plant or rock crusher

DESCRIPTION OF PROCEDURE

The appropriate emission factors were applied to process data for all identified batch plants and rock crushers. Each batch plant or crusher was assigned to a county according to its location of operation indicated on the ACEN. Emissions were totaled for all plants or crushers in a county.

BASE DATA

Colorado Air Pollution Control Division air contaminant emission notice files[6] were reviewed and process weight rates, control efficiencies, and locations for all portable plants were extracted.

ASSUMPTIONS

For batch plants without 1974 ACEN's, the plant was assumed to be operating in the county indicated on the latest ACEN.

EMISSION FACTORS

Uncontrolled emission factors were obtained from AP-42[2] and are as follows:

Asphalt batch plant = 15.0 lb/ton of asphalt
Concrete batch plant = 0.2 lb/yd^3 of concrete
Rock crusher = 0.1 lb/ton of product

The 15.0 lb/ton factor for asphalt batch plants assumes that all plants have a precleaner.

Table 17.1. 1974 PORTABLE INDUSTRIAL PROCESS EMISSIONS

(ton/yr)

County	Particulate
Adams	41
Arapahoe	neg
Boulder	neg
Clear Creek	neg
Denver	neg
Douglas	15
Gilpin	12
Jefferson	11
El Paso	8
Pueblo	neg
Larimer	15
Weld	2
Garfield	neg
Mesa	14
Moffat	23
Rio Blanco	neg

18. EVAPORATIVE LOSSES

PARAMETERS FOR ESTIMATING EMISSIONS

- Hydrocarbon evaporative emissions from dry cleaning and other sources, based on county populations
- Gasoline transfer hydrocarbon losses, based on vehicle miles traveled (VMT)

DESCRIPTION OF PROCEDURE

Dry cleaning and other hydrocarbon losses were estimated by using national per capita consumption factors. Point source hydrocarbon losses were subtracted to obtain area source emissions.

Gasoline transfer losses were estimated by applying emission factors to apportioned county gasoline sales. Gasoline sales were apportioned by dividing vehicle miles traveled for each county by an average miles per gallon factor of 12.2 mpg.[1]

BASE DATA

Population estimates for 1974 were obtained from Colorado Current Population Reports.[7] Vehicle miles traveled were obtained from the Colorado Department of Highways, as summarized in the AMV[23] and TRW[3] reports.

ASSUMPTIONS

1. All gasoline purchased in a county is used in that county.

2. Colorado is a cold climate relative to the average climate in the United States (used to determine dry cleaning and other hydrocarbon loss emission factors).

3. The source category "other hydrocarbon losses" includes all point source emissions and all area source emissions except dry cleaning and transfer losses.[1] In counties where reported point source emissions exceed the estimate for "other hydrocarbon losses" based on population, the other hydrocarbon losses are considered to be negligible. In these counties, area source hydrocarbon emission estimates consist of only dry cleaning and gasoline transfer losses.

4. Gasoline transfer to tank cars/trucks and to gasoline service stations is entirely by submerged loading operations.

EMISSION FACTORS

The following emission factors were obtained from APTD-1135:[1]

- Dry Cleaning Losses
  emission factor = 2.7 lb/capita/yr
- Other Hydrocarbon Losses

County population	Emission factor, lb/capita/yr
Less than 100,000	3
100,000- 500,000	8
500,000-1,000,000	18
More than 1,000,000	28

The following emission factors were obtained from AP-42:[2]

- Gasoline Transfer Losses

Operation	Emission factor, lb/1000 gal
Tank cars/trucks	4.10
Underground gasoline storage	7.30
Filling motor vehicle tanks	11.67
Total emission factor	23.07

Table 18.1. 1974 EVAPORATIVE HYDROCARBON EMISSIONS

(ton/yr)

County	Dry cleaning losses	Other HC losses	Gasoline transfer losses
Adams	290	185	1005
Arapahoe	261	671	859
Boulder	210	0	676
Clear Creek	10	7	138
Denver	602	3414	3082
Douglas	20	0	269
Gilpin	3	3	37
Jefferson	410	0	1350
Larimer	150	448	658
Weld	140	403	802
Garfield	20	26	167
Mesa	80	70	364
Moffat	10	10	86
Rio Blanco	10	9	42

19. INCINERATORS

PARAMETER FOR ESTIMATING EMISSIONS

- Individual source emission estimates from ACEN forms

DESCRIPTION OF PROCEDURE

Incinerators with emissions of less than five tons per year were not included in the point source inventory. These incinerators contribute only a small percentage of the total point source emissions and have, therefore, been treated as area sources.

BASE DATA

All data used to estimate emissions from the incinerators were obtained from the Colorado Air Pollution Control Division air contaminant emission notice files.[6]

EMISSION FACTORS

Factors were obtained from AP-42, p 2.1-3,[2] lb/ton of refuse incinerated:

Pollutant	Multiple chamber	Pathological
Particulate	7.0	8
Sulfur dioxide	2.5	neg
Carbon monoxide	10.0	neg
Hydrocarbons	3.0	neg
Nitrogen oxides	3.0	3

Table 19.1. 1974 INCINERATORS EMISSIONS

County	Partic	SO_2	CO	HC	NO_x
Adams	4		1	0	1
Arapahoe	7		5	1	7
Boulder	2		3	1	1
Clear Creek	3		0	0	1
Denver	3		5	2	2
Douglas	0		0	0	0
Gilpin	0		0	0	0
Jefferson	4		5	2	2
El Paso	4		1	0	0
Pueblo	2		6	0	0
Larimer	1		0	0	0
Weld	1		6	2	0
Garfield	1	1	0	0	0
Mesa	0	0	0	0	0
Moffat	0	0	0	0	0
Rio Blanco	0	0	0	0	0

20. UNPAVED ROADS

PARAMETERS FOR ESTIMATING EMISSIONS

- Vehicle miles traveled (VMT) on unpaved roads
- Average vehicle speeds

DESCRIPTION OF PROCEDURE

Emission factors were calculated and adjusted to each county for days without rain, average silt content of the roads, and average vehicle speed. Emission factors were multiplied by VMT on unpaved roads by county to estimate emissions from this category.

BASE DATA

The VMT for unpaved roads were obtained from the TRW[3] report. Days without rain were estimated using the map of precipitation frequency in AP-42, Supplement 5, p 95.[17]

ASSUMPTIONS

1. The 1973 VMT data are representative of 1974.
2. Vehicle speed is thirty miles per hour.
3. Average silt content on gravel surfaces or graded and drained roads is 12 percent.
4. Sixty percent (60%) of initial emissions are less than 30 μ in diameter and, therefore, remain suspended.

5. The VMT on unimproved roads and trails are insignificant.

EMISSION FACTORS

Reference: AP-42, Supplement 5.[17]

$$E = (0.6) \times (0.81) \times (s) \times (S/30) \times \{(365-W/365)\} \quad \text{(eq.2)}$$

where E = emission factor, lb/annual VMT

s = silt content of road surface

S = average vehicle speed, mi/hr

W = number of days with 0.01 inches or more of rain

0.6 = fraction of emissions remaining suspended

Table 20.1. 1974 PARTICULATE EMISSIONS AND PARAMETERS FOR ESTIMATING EMISSIONS FOR UNPAVED ROADS

County	Annual 10^3 VMT,	Days of rainfall	Emission factor, lb/ton	Particulate emissions, ton/yr
Adams	8,943	90	4.4	19,675
Arapahoe	6,274	90	4.4	13,803
Boulder	6,796	110	4.1	13,932
Clear Creek	1,482	120	3.9	2,890
Denver	591	90	4.4	1,300
Douglas	4,316	110	4.1	8,848
Gilpin	1,438	120	3.9	2,804
Jefferson	13,501	110	4.1	27,677
El Paso	24,196	90	4.4	53,231
Pueblo	7,964	90	4.4	17,521
Larimer	12,384	120	3.9	24,149
Weld	28,229	90	4.4	62,104
Garfield	9,439	90	4.4	20,766
Mesa	11,213	90	4.4	24,669
Moffat	55,111	90	4.4	33,244
Rio Blanco	5,504	90	4.4	12,109

21. PAVED ROADS

PARAMETER FOR ESTIMATING EMISSIONS

- Vehicle miles traveled (VMT) on paved roads

DESCRIPTION OF PROCEDURE

Dust from paved roads was broken down into two categories:

1. Dust from sand used for snow control was calculated using total paved urban VMT on days following sand applications (estimated 18 days in 1974). In the Denver AQMA, the total paved VMT were multiplied by the fraction of the county population that is urban to obtain urban VMT. In other areas, urban VMT as calculated by AMV[23] were used.

2. Dust emissions from paved roads during all other periods of the year were estimated from the total paved VMT. The eighteen days with higher emission rates following sanding were subtracted out to prevent duplication.

BASE DATA

The VMT information was obtained from AMV 1975 projections,[23] except in the Denver AQMA where data were taken from the TRW[3] report. Estimates of heavy snowfall (12 days per year) were obtained from the Denver Highway Maintenance Department.[35] This yielded approximately 18 days of dry sanded roads (1.5 days per heavy snowfall).[4] Days with 0.01 inches or more of precipitation were obtained from AP-42,

Supplement 5, p 95.[17] The emission factors of 0.17 lb/VMT and 0.00385 lb/VMT were derived previously from The Measurement, Cost, and Control of Traffic Dust in Seattle's Dumwamish Valley[36] and have been used in other AQMA studies. Unpaved road VMT were taken from the TRW[3] report. Other input data were taken from the 1972 PEDCo[4] study.

ASSUMPTIONS

1. Sanding occurs only on urban roads.
2. Eighty percent (80%) of the average daily traffic (ADT) volume occurs during periods after the snow has melted.
3. Seventy percent (70%) of the total urban vehicle miles were traveled on roads which were sanded for snow control.

EMISSION FACTORS

Factors were calculated as follows:

° Dust from sand used for snow control

$$E = (0.17 \text{ lb/annual VMT}) \times (18/365) \qquad \text{(eq.3)}$$

° Dust from paved roads

$$E = (0.00385 \text{ lb/annual VMT}) \times (365-W-18)/365 \qquad \text{(eq.4)}$$

where W = days of 0.01 inches or more of rain

Table 21.1. 1974 REINTRAINED DUST FROM PAVED ROADS

(ton/yr)

County	Dust from snow controlled roads	Dust from paved roads	Total dust from paved roads
Adams	2231	1431	3662
Arapahoe	1910	1225	3135
Boulder	1333	887	2220
Clear Creek	neg	171	171
Denver	7664	4424	12088
Douglas	neg	387	387
Gilpin	neg	26	26
Jefferson	2681	1784	4465
El Paso	3260	2382	5642
Pueblo	neg	1015	1015
Larimer	527	819	1346
Weld	403	1118	1837
Garfield	neg	227	227
Mesa	474	507	981
Moffat	neg	103	103
Rio Blanco	neg	53	53

22. AGRICULTURE

PARAMETER FOR ESTIMATING EMISSIONS

- Acres of crops planted in each county

DESCRIPTION OF PROCEDURE

The wind erosion equation was used to calculate windblown dust. Emission factors in the PEDCo[4] study were used to update emissions for the Front Range AQMA's. Emission factors were calculated for the Oil Shale AQMA counties and used to estimate windblown dust.

Dust from agricultural tillage operations was calculated using the formula and methods described in AP-42, Supplement 5.[17] Dust from tillage was shown to be insignificant in comparison with windblown dust on an annual basis and is, therefore, not shown in this analysis. The PEDCo[4] study indicated similar findings.

BASE DATA

Acreages of various crop types were obtained from Colorado 1974 Agricultural Statistics.[37] Emission factors for windblown dust were calculated according to the procedures outlined in Development of Emission Factors for Fugitive Dust Sources.[38] Parameters used in the calculations were determined from graphs, maps, and charts in that reference. For the Front Range AQMA's, emission factors calculated in the PEDCo[4] study were used.

ASSUMPTIONS

1. Acres planted have not changed significantly since 1973.

2. Emission factors have not changed since the 1972 PEDCo[4] study.

EMISSION FACTORS

Factors for windblown dust were calculated according to the following equation:

$$E = (a) \times (I) \times (K) \times (C) \times (L') \times (V') \quad \text{(eq.5)}$$

where E = emission factor, ton/acre/yr

a = portion of total wind erosion losses that would be measured as particulates, estimated at 0.025

I = soil erodibility, ton/acre/yr

K = surface roughness factor

C = climatic factor

L' = unsheltered field width factor

V' = vegetative cover factor

Emission factors were calculated separately for each crop type, e.g., corn, wheat, beans, etc. The emission factors were then multiplied by the acres of that crop. Crop acres in each county are shown in Table 22.1.

Table 22.1. 1974 TOTAL CROP ACREAGE AND AGRICULTURAL EMISSIONS

County	Total acres	Particulate emissions, ton/yr
Adams	16,000	3,478
Arapahoe	3,900	1,209
Boulder	19,300	4,819
Clear Creek	0	0
Denver	0	0
Douglas	1,000	215
Gilpin	0	0
Jefferson	700	196
El Paso	50,260	13,293
Pueblo	20,980	4,118
Larimer	67,600	14,472
Weld	337,500	52,229
Garfield	2,030	438
Mesa	16,180	2,223
Moffat	31,900	296
Rio Blanco	700	92

23. LAND DEVELOPMENT

PARAMETER FOR ESTIMATING EMISSIONS

- Acres of land disturbed from grading and road building to provide access to plats

DESCRIPTION OF PROCEDURE

The number of acres developed (providing road access) was estimated, and from this the number of acres exposed to the wind. A wind erosion factor was applied to estimate emissions. The total number of acres developed by 1974 was assumed to be one half the acres reported in the 1972 PEDCo[4] study, plus new acreage platted in 1974, since some of the previously disturbed land (prior 1972) had returned to its natural state.

BASE DATA

The number of acres platted prior to 1972 was obtained from the PEDCo[4] study. The number of new acres platted in 1974 was obtained from the county planning agencies.

ASSUMPTIONS

1. Activity on pre-1972 subdivided land decreased in 1974 because of bankruptcies declared by land development companies.

2. Land exposed for more than one year returns to its natural state, or road maintenance is acquired by the county highway department.

EMISSION FACTORS

The emission factor is based on a climatic factor and the number of acres of graded roadway exposed to wind erosion:

$$E = 0.13\ (C) \qquad \text{(eq.6)}$$

where E = emission factor, ton/acre of land exposed

C = climatic factor from wind erosion equation

Table 23.1. 1974 LAND DEVELOPMENT EMISSIONS

County	Acres exposed	Emission factor, ton/acre/yr	Particulate emissions, ton/yr
Adams	4002	0.078	312
Arapahoe	3466	0.078	270
Boulder	730	0.078	57
Clear Creek	150	0.026	3
Denver	0	0.078	0
Douglas	6652	0.078	519
Gilpin	25	0.026	0
Jefferson	2891	0.078	225
El Paso	46963	0.078	3663
Pueblo	5886	0.078	459
Larimer	2742	0.078	214
Weld	501	0.078	39
Garfield	2263	0.059	132
Mesa	410	0.065	26
Moffat	0	0.052	0
Rio Blanco	0	0.052	0

24. QUARRYING, MINING, AND TAILINGS

PARAMETERS FOR ESTIMATING EMISSIONS

- Acres of tailings from mine operations
- Acres of sand and gravel stockpiles at quarries

DESCRIPTION OF PROCEDURE

Acreages used in the 1972 PEDCo[4] study were checked and considered representative for 1974. The Oil Shale AQMA counties were estimated at ten acres per mine.

BASE DATA

The PEDCo[4] study was used for all mines and quarries in the Front Range. The Colorado Bureau of Mines[39] was contacted to check the 1972 data and obtain information on the Oil Shale AQMA.

ASSUMPTIONS

An average of ten acres per mine or quarry was assumed when data were not available.

EMISSION FACTORS

The emission factor of 9.2 tons per acre per year was obtained from the 1972 PEDCo[4] study and corrected using the

climatic factor (C). The corrected emission factor for each county is shown in Table 24.1.

Table 24.1. 1974 QUARRYING, MINING, AND TAILINGS EMISSIONS

County	Total acreage	Emission factor, ton/acre/yr	Particulate emissions, ton/yr
Adams	40	8.0	320
Arapahoe	52	8.0	416
Boulder	169	8.0	1352
Clear Creek	645	2.2	1419
Denver	0	8.0	0
Douglas	41	8.0	328
Gilpin	15	2.2	33
Jefferson	132	8.0	1056
El Paso	0	8.0	0
Pueblo	13	9.0	104
Larimer	315	8.0	2520
Weld	11	8.0	88
Garfield	20	8.0	160
Mesa	10	8.0	80
Moffat	10	8.0	80
Rio Blanco	0	8.0	0

25. AGGREGATE STORAGE

PARAMETER FOR ESTIMATING EMISSIONS

- Tons of aggregate stored

DESCRIPTION OF PROCEDURE

A four month supply of aggregate was estimated for all stationary asphalt or concrete batch plants. The amount processed during the four months was calculated for each batch plant and totaled to obtain tons of aggregate stored for each county.

BASE DATA

Colorado Air Pollution Control Division air contaminant emission notice files[6] were reviewed and the process weight rates of all stationary asphalt and concrete batch plants were obtained.

ASSUMPTIONS

1. Aggregate storage at quarries is not included in this section.
2. Aggregate is stored at the quarry when a portable batch plant is operating.

EMISSION FACTORS

Factors were calculated using the following equation:

$$E = 0.33 \div (PE^2/100^2) \qquad \text{(eq.7)}$$

where E = emission factor, lb/ton of aggregate stored

PE = Thornthwaite's precipitation-evaporation index

Table 25.1. 1974 AGGREGATE STORAGE EMISSIONS

County	Aggregate stored, tons	PE	Emission factor, lb/ton	Particulate emissions, ton/yr
Adams	507,810	43	1.78	453
Arapahoe	229,017	43	1.78	204
Boulder	0	43	1.78	0
Clear Creek	0	43	1.78	0
Denver	65,333	43	1.78	58
Douglas	226,667	43	1.78	202
Gilpin	0	43	1.78	0
Jefferson	133,333	43	1.78	119
El Paso	60,000	38	2.28	68
Pueblo	91,333	38	2.28	104
Larimer	0	43	1.78	0
Weld	37,433	43	1.78	33
Garfield	9,333	51	1.26	5
Mesa	81,230	51	1.26	51
Moffat	0	51	1.26	0
Rio Blanco	11,966	51	1.26	7

26. CATTLE FEEDLOTS

PARAMETER FOR ESTIMATING EMISSIONS

- Number of cattle on feed

DESCRIPTION OF PROCEDURE

The number of cattle on feed was multiplied by the estimated emission factor for that county. Assumptions and techniques used to estimate emission factors were taken from the 1972 PEDCo[4] study.

BASE DATA

The 1974 data on the number of cattle on feed were obtained from the Colorado 1974 Agricultural Statistics,[37] as shown in Table 26.1.

ASSUMPTIONS

1. The control efficiency of the feedlot varied inversely with the size.
2. The size of the feedlot was estimated to increase as the number of cattle on feed in a county increased.
3. Counties with less than 1000 head were neglected.

EMISSION FACTORS

A weighted average emission factor was calculated as follows:

$$EF = \left(\frac{\%\ \text{cattle}}{\text{controlled}}\right) \times \left(\frac{\text{controlled}}{EF}\right) + \left(\frac{\%\ \text{cattle}}{\text{controlled}}\right) \times \left(\frac{\text{uncontrolled}}{EF}\right) \qquad \text{(eq.8)}$$

where EF = emission factor, ton/1000 head/yr

The calculated emission factor for each county is shown in Table 26.1. An emission factor of 8 tons per year per 1000 head of cattle was used for uncontrolled dust (no watering) and an emission factor of 1.2 tons per year per 1000 head of cattle was used for controlled dust (watering at 85 percent efficiency).

Table 26.1. 1974 CATTLE FEEDLOT EMISSIONS

County	1974 Cattle on feed	Assumed percent of cattle controlled	Emission factor ton/1000 head/yr	1974 Particulate emissions, ton/yr
Adams	33,500	65	3.5	117
Arapahoe	neg			
Boulder	28,000	65	3.5	98
Clear Creek	neg			
Denver	neg			
Douglas	neg			
Gilpin	neg			
Jefferson	neg			
El Paso	neg			
Pueblo	12,500	65	3.5	43
Larimer	29,000	65	3.5	101
Weld	359,000	90	1.9	682
Garfield	neg			
Mesa	neg			
Moffat	neg			
Rio Blanco	neg			

27. CONSTRUCTION

PARAMETER FOR ESTIMATING EMISSIONS

- Acres of active construction per year

DESCRIPTION OF PROCEDURE

The number of building permits issued for residential construction and estimated average construction areas per new housing unit were used to calculate residential construction acreage. Commercial and industrial construction estimates were based on either the dollar value of construction projects or the number of permits issued.

Highway construction projects were identified from monthly reports of the State Highway Department. For those projects involving grading (new construction or regrading), the acreage was estimated from the reported length of the project times an approximate width which was a fraction of the number of highway lanes. The duration of each project was determined from the reported starting date and scheduled completion date.

BASE DATA

County building departments provided data on number of permits issued and dollar value of construction. The monthly highway construction reports for 1974 were obtained from the State Highway Department.

Factors to convert construction cost into equivalent acreage were obtained from the EPA report, Development of Emission Factors for Fugitive Dust Sources:[38]

Commercial - 2.5 acres/million $
Industrial - 3.0 acres/million $

The values were updated from 1973 to 1974 by using the Engineering Construction Cost Index rates of 1.15:

Commercial - 2.17 acres/million $
Industrial - 2.60 acres/million $

ASSUMPTIONS

1. All permits issued in 1974 resulted in construction during 1974.
2. Construction of single-family housing disturbs an average of 1/6 acre for three months; multiple-family dwellings occupy an average of 1/2 acre and construction lasts about four months.
3. Commercial and industrial construction has an average duration of eight months.
4. A two lane highway requires a 20 foot width of regrading. A multilane highway has an average 100 foot width of regrading.
5. A 50 percent reduction in emissions occurs as a result of enforcement of fugitive dust control regulations.

EMISSION FACTOR

An unadjusted emission factor of 1.2 tons per acre of construction per month of activity (AP-42, p 11.2-4)[2] was applied for both building and highway construction. This

value was corrected to reflect climatic conditions by using Thornthwaite's precipitation-evaporation index, as shown below:

$$\text{Emission factor} = (1.2)\ \frac{(\text{PE test area})^2}{(\text{PE for AQMA})^2} \qquad \text{(eq.9)}$$

where PE test area = 31
PE Denver = 43
PE Larimer-Weld = 43
PE El Paso = 38
PE Pueblo = 38
PE Oil Shale Area = 51

Table 27.1. BUILDING CONSTRUCTION ACTIVITY IN AQMA COUNTIES

County	Residential bldg. permits Single	Multiple	Value of construction, million $ Commercial	Institutional	Industrial
Adams	119	43	4.7	3.8	11.8
Arapahoe	585	77	7.2	-	7.2
Boulder	156	340	0.8	1.9	1.2
Clear Creek	46	0	-	0.4	-
Denver	451	165	63.0	20.0	5.0
Douglas	485	5	-	-	-
Gilpin	42	0	-	-	-
Jefferson	1379	28	1.0	6.0	1.6
El Paso	737	127	11.1	11.5	28.0
Pueblo	289	0	0.3	0.4	4.3
Larimer	519	26	2.5	0.1	2.5
Weld	178	3	3.0	2.5	3.5
Garfield	88	4	1.0	0.1	-
Mesa	581	56	1.9	2.3	2.0
Moffat	44	1	-	0.4	0.2
Rio Blanco	16	0	0.3	-	0.8

Table 27.2. 1974 CONSTRUCTION EMISSIONS

County	Total acre-months of construction	Particulate emissions, ton/yr
Adams	1363	423
Arapahoe	935	290
Boulder	978	303
Clear Creek	32	10
Denver	2542	788
Douglas	364	113
Gilpin	25	8
Jefferson	1131	350
El Paso	1712	685
Pueblo	518	207
Larimer	730	226
Weld	948	294
Garfield	725	160
Mesa	561	124
Moffat	147	32
Rio Blanco	30	7

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